

Aerial Survey of Seabirds and Marine Mammals at Kaula Island, Hawaii, July 2025

GSA #47QRAA23D002Z

Delivery Order # N62742-23-F-9952

Prepared For

U.S. Navy
Commander, U.S. Pacific Fleet Environmental Readiness
250 Makalapa Drive
Pearl Harbor, HI 96860

Via

NAVFAC Pacific, EV51
258 Makalapa Drive, Suite 100
Pearl Harbor, HI 96860

Prepared By

Normandeau Associates, Inc.
13100 Tech City Circle, Suite 500
Alachua, FL 32615
(352) 372-4747

www.normandeau.com



and

Air Data Solutions
502 Airport Road
Natchitoches, LA 71457

airdatasolutions.com



January 2026

This page intentionally left blank.

Contents

<i>List of Tables</i>	<i>iv</i>
<i>List of Figures</i>	<i>iv</i>
<i>Executive Summary</i>	<i>vii</i>
1 Introduction	1
2 Methods	3
2.1 Weather Conditions and Survey Limitations	3
2.2 Survey Design	3
2.2.1 Vertical Surveys	4
2.2.2 Oblique Surveys	7
2.3 Identification and Quality Assurance	7
2.4 Data Analysis and Enumeration	7
3 Results	8
3.1 Species Abundance	8
3.2 Species Distribution	11
3.2.1 Occurrence of Birds and Marine Mammals	11
3.2.2 Blue-billed White-Tern (new name following Clements [2025])	12
3.2.3 Brown Noddy	12
3.2.4 Black Noddy	12
3.2.5 Sooty Tern	12
3.2.6 Grey-backed Tern	12
3.2.7 Unknown Terns and Noddies	12
3.2.8 White-tailed Tropicbird	12
3.2.9 Red-tailed Tropicbird	13
3.2.10 Tropicbird species	13
3.2.11 Laysan Albatross	13
3.2.12 Black-footed Albatross	13
3.2.13 Band-rumped Storm-Petrel ** Endangered Species	13
3.2.14 Christmas Shearwater	13
3.2.15 Great Frigatebird	13
3.2.16 Red-footed Booby	13
3.2.17 Brown Booby	13
3.2.18 Masked Booby	14
3.2.19 Booby Species Unknown (Masked/Red-footed/Brown)	14
3.2.20 Masked Booby / Red-footed Booby	14
3.2.21 Masked Booby / Brown Booby	14
3.2.22 Dead Birds	14
3.2.23 Hawaiian Monk Seal ** Endangered Species	14
4 Discussion	37
5 References	39
6 Appendices	40
Appendix I. Scientific Names of Relevant Bird and Mammal Species	40

Appendix II. Survey Imagery: Vertical Image Examples. Note: Image resolution is reduced in this format	41
Appendix III. Results of Bird Surveys Conducted on Kaula Island, Hawaii (1932–2025)*	44
Appendix IV. Estimates of Seabird Numbers and Estimated Pairs During the July 2025 Aerial Digital Survey of Kaula Island, Hawaii.....	46
Appendix V: Comparison of Estimated Density (per m²) of Seabirds August 2023 and July 2025 Using Vertical Imagery Only.....	47
Appendix VI. Survey Imagery: Density Comparison Image Examples.....	48
Appendix VII. Results of Aerial Digital Surveys of Kaula Island, Hawaii (2013–2025)*	50

List of Tables

Table 3–1. Number of Live Birds (in taxonomic order [Clements 2025]) and Marine Mammals Recorded on Kaula Island by Vertical and Oblique Surveys on July 28, 2025	8
Table 3–2. Comparison of Species, Age, and Numbers of Flying and Sitting Birds Recorded in August 2023 and July 2025 Aerial Surveys.....	16

List of Figures

Figure 1-1. Location of Kaula Island relative to the main Hawaiian Islands (inset) and Kauai and Niihau (imagery from ESRI).	2
Figure 1-2. Topography of Kaula Island.....	2
Figure 2-1. Depiction of Vertical (nadir) and Oblique Imagery Collection	4
Figure 2-2. Kaula Island image analysis grid.	6
Figure 3-1. Relative abundance of species groups encountered in the July 2025 survey.....	10
Figure 3-2. Relative abundance by species encountered in the July 2025 survey.	11
Figure 3-3. Distribution of all birds and marine mammals recorded on Kaula Island during the July 2025 survey.	15
Figure 3-4. Distribution of blue-billed white-tern and grey-backed tern recorded on Kaula Island during the July 2025 survey.	17
Figure 3-5. Distribution of brown noddies recorded on Kaula Island during the July 2025 survey.	18
Figure 3-6. Distribution of black noddies recorded on Kaula Island during the July 2025 survey.	19

Figure 3-7. Distribution of sooty tern recorded on Kaula Island during the July 2025 survey.	20
Figure 3-8. Distribution of unknown tern/noddy recorded on Kaula Island during the July 2025 survey.....	21
Figure 3-9. Distribution of white-tailed tropicbird recorded on Kaula Island during the July 2025 survey.....	22
Figure 3-10. Distribution of red-tailed tropicbird recorded on Kaula Island during the July 2025 survey.....	23
Figure 3-11. Distribution of unidentified tropicbird recorded on Kaula Island during the July 2025 survey.....	24
Figure 3-12. Distribution of Laysan and black-footed albatross recorded on Kaula Island during the July 2025 survey.	25
Figure 3-13. Distribution of band-rumped storm-petrel recorded on Kaula Island during the July 2025 survey.....	26
Figure 3-14. Distribution of Christmas shearwater recorded on Kaula Island during the July 2025 survey.....	27
Figure 3-15. Distribution of great frigatebird recorded on Kaula Island during the July 2025 survey.	28
Figure 3-16. Distribution of red-footed booby recorded on Kaula Island during the July 2025 survey.	29
Figure 3-17. Distribution of brown booby recorded on Kaula Island during the July 2025 survey.	30
Figure 3-18. Distribution of masked booby recorded on Kaula Island during the July 2025 survey.	31
Figure 3-19. Distribution of booby species unknown (Masked/Red-footed/Brown) recorded on Kaula Island during the July 2025 survey.	32
Figure 3-20. Distribution of masked/red-footed booby recorded on Kaula Island during the July 2025 survey.....	33
Figure 3-21. Distribution of masked/brown booby recorded on Kaula Island during the July 2025 survey.....	34
Figure 3-22. Distribution of dead birds recorded on Kaula Island during the July 2025 survey.	35
Figure 3-23. Distribution of Hawaiian monk seals recorded on Kaula Island during the July 2025 survey.....	36
Figure 6-1. White-tailed tropicbird during the July 2025 survey.	41
Figure 6-2. Red-tailed tropicbird during the July 2025 survey.....	41
Figure 6-3. Laysan albatross during the July 2025 survey.	41
Figure 6-4. Christmas shearwater during the July 2025 survey.....	41

Figure 6-5. Great frigatebird during the July 2025 survey.	42
Figure 6-6. Red-footed booby during the July 2025 survey.	42
Figure 6-7. Brown booby during the July 2025 survey.	42
Figure 6-8. Masked booby during the July 2025 survey.....	42
Figure 6-9. Hawaiian monk seals resting on ledges during the July 2025 survey.	43
Figure 6-10. Area with brown noddies during the August 2023 survey.....	48
Figure 6-11. Same location during the July 2025 survey.	49

Executive Summary

An aerial digital survey of Kaula was conducted on July 28, 2025. Ultra-high-resolution digital still images were collected using a manned turbo prop twin-engine survey aircraft. A vertical (nadir) survey covered 100% of the top of the island, and this survey was complemented by an oblique survey completed on the same day. Carrying out both surveys allows counts to be made of birds on the top of the island and those on the cliff faces.

Vertical survey imagery was collected at 1.5-cm resolution at sea level and at the higher elevation sections of the island; the flight guidance system facilitates raising or lowering of flight altitude depending on terrain. Oblique survey imagery was collected at better than 2.5-cm resolution.

Carried out as part of the Navy monitoring program, the survey was designed to assess the seabird populations on Kaula Island and provide georeferenced ultra-high-resolution imagery. The images collected have been analyzed and quality assured, and the raw counts of animals recorded are presented in this report.

Two species listed as endangered for Hawaiian populations and protected under the U.S. Endangered Species Act were encountered: a band-rumped storm-petrel and Hawaiian monk seal.

Although both the 2023 and 2025 surveys were undertaken using the same survey methodology, total numbers were much lower in 2025 than in 2023 but with greater species diversity. In 2023 there were 17,638 individuals recorded of 9 species. During the 2025 survey, 6,697 birds representing 15 species were recorded with red-footed booby being the most abundant species (n=1,417) followed by brown noddy (n=1,238), brown booby (n=1,160), masked booby (n=733), red-tailed tropicbird (n=632) and sooty tern (n=348). Other species recorded include blue-billed white-tern (new taxonomy following Clements [2025]), grey-backed tern, black noddy, red-tailed and white-tailed tropicbirds, Laysan and black-footed albatrosses, great frigatebird, and over-water records of Christmas shearwater and one endangered band-rumped storm-petrel. Fifteen dead birds (one frigatebird and 14 boobies) were observed during the surveys.

When comparing the results in the numbers of brown noddy between the survey of July 28, 2025, with those of August 3, 2023, the differences are dramatic with 1,238 individuals recorded in 2025 compared to 11,034 recorded in 2023. However, the survey undertaken on July 21, 2021, recorded 3,456 individuals, which suggests that the timing of nesting may vary interannually and be partly responsible for the apparent decrease in numbers of noddies encountered. A review of weather conditions for two months prior to the 2025 survey found no extreme events except for some elevated trade winds.

Numbers of great frigatebird (n=711) were similar to those recorded in August 2018 (n=719), greater than during August 2023 (n=377), and lower than July 2021 (n=1,375). Historically, numbers of great frigatebird have fluctuated.

Although densities of species were generally lower than in previous years, distributions of all species recorded remain similar.

At the time of the surveys, 13 endangered Hawaiian monk seals were recorded resting on ledges mostly on the west side of the island with one individual on the east side of the island.

1 Introduction

This study was designed to meet the objectives of the Navy monitoring program resulting from a coastal zone management act consistency determination with the State of Hawaii. The research is designed to monitor the status of the seabird populations on Kaula Island and support the Navy's GeoReadiness repository which provides data to determine potential effects of Military Readiness Activities (DON 2009). Normandeau Associates was contracted by the U.S. Navy to provide ornithological data for the Pacific Island of Kaula, Hawaii, through the capture and analysis of georeferenced ultra-high-resolution aerial digital imagery.

Kaula Island is a small (0.64 km^2), uninhabited crescent-shaped islet in the western chain of islands making up the Hawaiian Archipelago (Figure 1–1 and Figure 1–2). The islands closest to Kaula are Niihau (37 km northeast) and Kauai (approximately 111 km northeast). A mountain ridge runs along the length of Kaula Island (approximately 1,676 m), which at its highest point is 164.6 m above sea level (Palmer 1936). The terrain drops steeply from the ridge crest at a mean slope of 36° , and steep V-shaped ravines have been cut by ephemeral streams on the windward slopes such that the island has little level terrain (Elmer and Swedberg 1971). The northern horn of the island extends 762 m from the summit and ends at an elevation of approximately 85 m while the southern horn extends 914 m from the summit and ends at an elevation of approximately 30 m (Palmer 1936).

Since 1952, the U.S. Navy has used the southeastern tip of the island (approximately 0.06 km^2) as a range to train aviators in air-to-surface and surface-to-surface weapons delivery. Both live and inert ordnance were used during training missions until the end of 1980. Since 1981, munitions training and aerial gunnery exercises undertaken by the U.S. Navy at Kaula have been restricted to inert ordnance (non-explosive) delivery (DON 2008; DON 2013).

Eleven land-based avian surveys were undertaken historically on the island (reviewed in Pepi et al. 2009), but due to safety reasons these were replaced with boat-based and aerial observations (2009–2011; Pepi et al. 2009; DON 2009, 2011).



Figure 1-1. Location of Kaula Island relative to the main Hawaiian Islands (inset) and Kauai and Niihau (imagery from ESRI).



Figure 1-2. Topography of Kaula Island.

The U.S. Navy replaced the boat-based surveys in 2013 when aerial digital imagery using improved technology became available. Twelve aerial digital surveys have now been conducted to date. This technology has resulted in the following improvements over prior efforts:

- Increased count accuracy through post-hoc, quantitative analysis of imagery rather than near-instantaneous live counts by observers in the field
- Increased count accuracy through elimination of bird disturbance effects from low-flying helicopters
- Increased count accuracy and bird identification ability on Kaula (previously surveyed by boat) because of increased visibility of the higher sections and slopes of the island.

2 Methods

2.1 Weather Conditions and Survey Limitations

This section explains some of the weather conditions and survey limitations encountered during the 2025 survey of Kaula.

The window of airspace reserved for survey was July 28 through July 31, 2025. No extreme weather systems for the area preceded the first proposed survey date, and clear skies over the island provided ideal conditions for imagery collection. The survey was conducted on July 28, 2025. Only one day was needed to complete the survey.

The aerial imagery equipment was installed into the aircraft early on July 28, 2025, and a short test flight was successfully conducted. The survey of Kaula began at solar noon on July 28, 2025, maximizing solar illumination of both sides of the island and limiting overshadowing from the island terrain.

Weather conditions were good with some patchy high cloud cover and mainly clear skies over the island. There was a mean wind speed of 15 knots from the southeast and visibility greater than 10 km throughout the survey.

2.2 Survey Design

This aerial digital survey of Kaula (July 28, 2025) included two types of imagery capture: vertical and oblique (Figure 2-1).

Ultra-high-resolution digital still images were collected using a manned turbo prop twin-engine survey aircraft (Piper Chieftain N812TB), which has a higher safety rating than piston twin-engine aircraft. The camera system included an industry leading GPS-linked flight management system (PhaseOne Pas280) specifically configured to target high-resolution surveys for birds and marine mammals.

Flight planning software was used to define the required flying altitude and speed according to the camera, lens, and required pixel resolution. During the survey, each transect was flown using a GPS-guided management system, and the image acquisitions were automatically triggered at predefined positions.

Due to the wide range of topographical features on Kaula, two types of imagery capture were performed to ensure that high-quality imagery was achieved over the whole island (100% coverage), including capturing animals on horizontal and vertical ledges. The first complete aerial survey was performed near solar noon on July 28, 2025, at higher altitude (vertical survey). The second, low-altitude survey (oblique survey) was completed immediately after.

The vertical high-altitude survey was conducted between 13:30 and 14:45 at 335–396 m (1,100–1,300 ft) and flown in a north–south direction. This survey captured imagery at 1.5-cm resolution at sea level and at the higher elevation sections of the island; the flight guidance system facilitates raising or lowering of flight altitude depending on terrain.

The oblique survey was carried out between 14:45 and 15:00 at 274–366 m (900–1,200 ft) by flying clockwise several times around the island. Although resolution of the oblique imagery varies, most images were collected at better than 2.5-cm resolution.

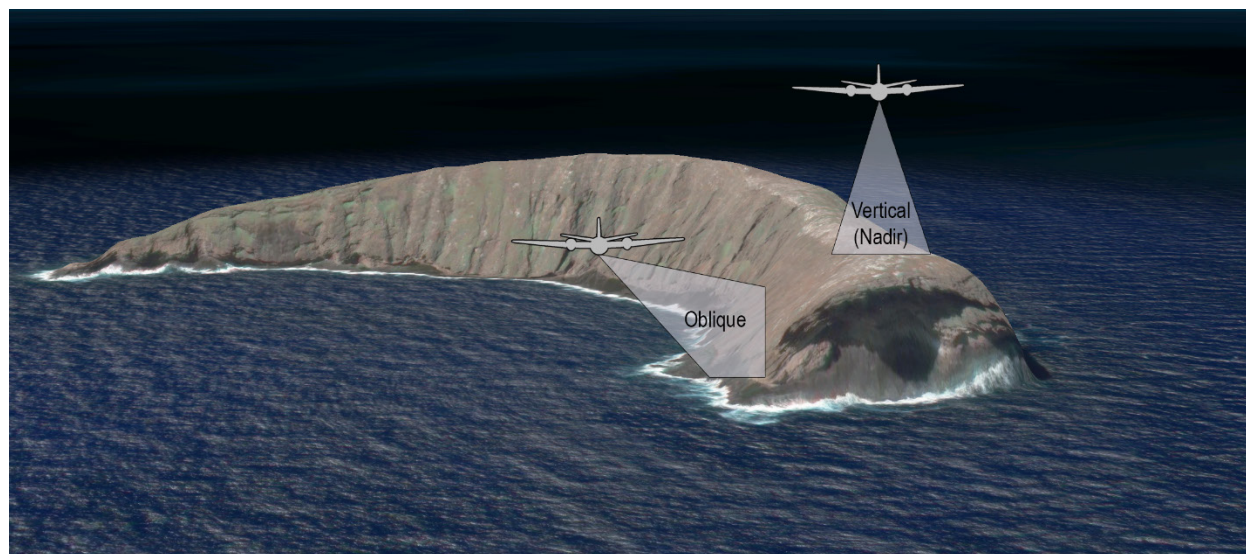


Figure 2-1. Depiction of vertical (nadir) and oblique imagery collection.

2.2.1 Vertical Surveys

As it is not technically possible to capture the entire island at 1.5-cm resolution in one single image, several flight-transects were conducted to ensure full coverage of the island with imagery at 1.5-cm resolution. Approximately 477 vertical digital photographs were generated over approximately 1 hour. These images were processed and imported into Corrilator3D (Image Mosaic Software) and joined to create one large image mosaic for the whole island. Images with the highest resolution for each location on the island were selected to compile the mosaic, and any overlapping image sections were removed. This method was the most appropriate to minimize the risk of double counting that might have otherwise occurred by treating each individual image in isolation (due to overlapping areas). A small probability exists that the movement of birds between transects could result in double counting; however, an equally small probability exists that a bird could be missed in both transects. On this basis, it is reasonable to assume that the risk of double counting is equal to the risk of undercounting, and the effect on the population count is negligible.

Overall, this survey method produces a smaller margin of error compared with other visual census techniques for birds that encompass a higher degree of disturbance and longer duration.

The mosaic was loaded into Global Mapper and defined into a 5×5 grid covering Kaula Island (Figure 2-2) and overlapping sections of imagery were removed. The images were further subdivided into 300×300 -pixel grid cells ($25 \text{ m} \times 25 \text{ m}$) representing 625 m^2 (Figure 2-2). Each defined grid cell was then analyzed for animal presence.

Specially trained staff reviewed each grid cell to provide center-point locations for individual animals. Images (snags) were created around each point, with each snag representing an individual animal. These were then sent to Normandeau biologists to ascribe the following information:

- Bird/mammal species by common name (see Appendix I for scientific names)
- Behavior (sitting, flying, deceased)
- Association ([1 adult, 2 adults, and juvenile, with combinations] nest, and none)
- Age (adult, juvenile, and unknown)
- Count of additional animals if missed in snag creation
- Position (exact location of animal using easting and northing coordinates)
- Date and time stamp of image collection
- Comments (additional useful information including size measurements when taken)

Each grid cell was analyzed in GlobalMapper, a GIS software. The software allows the grid cells to be loaded in and georeferenced. As part of the identification process, a center point containing location information was dropped on each target identified. Two full scans of each grid cell are manually completed to find targets for identification and provide confirmation that nothing is missed. The resolution of the images is extremely high, such that the individuals can be identified to species with a high degree of certainty.

Survey data were analyzed to produce maps showing bird and marine mammal distribution in a GIS format. For each map, bird and mammal observations were composed of individual points geo-referenced to actual spatial locations at the time of sighting. Examples of vertical imagery can be found in Appendix II.

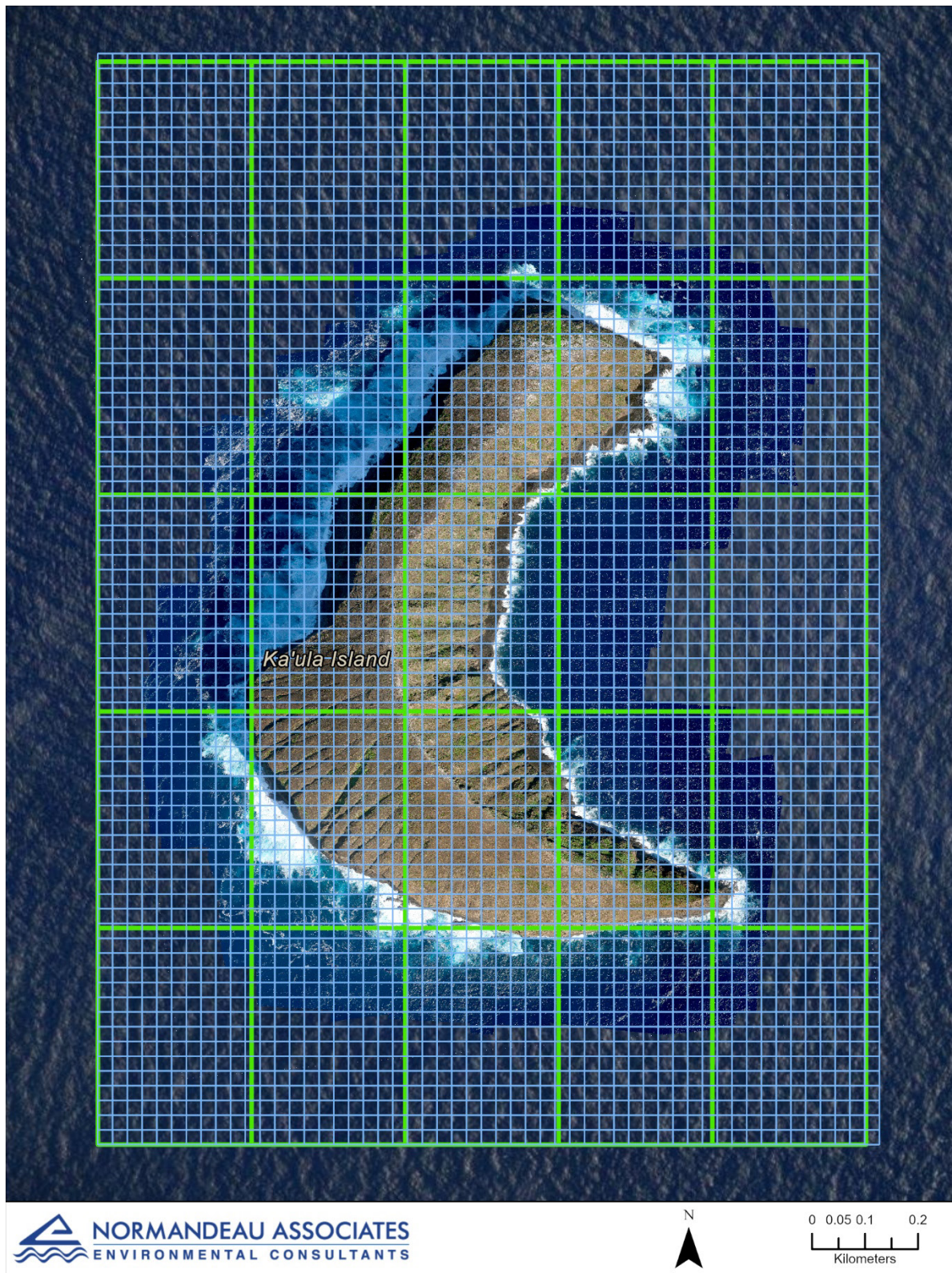


Figure 2-2. Kaula Island image analysis grid.

Compiled images from the vertical survey were joined to cover Kaula Island. The compiled image was analyzed in grid cell sections shown.

2.2.2 Oblique Surveys

The oblique images were spatially correlated against features in the vertical dataset to ensure correct spatial placement of each image. These images were then loaded into imagery software that tracks pixel X,Y values, and snags were created from each animal's center-pixel X,Y value with each snag representing an individual animal. Identification and enumeration of birds and marine mammals not visible in the vertical imagery due to the presence of steep cliffs, small caves, and overhanging rock ledges was completed using these oblique images. The results of the counts were subjected to a slightly different process than the vertical survey, as oblique imagery cannot be made into a mosaic. Quality assurance on oblique imagery included cross-reference of areas visible from the vertical survey to avoid double counting and was similarly completed by two manual reviews to confirm target extraction accuracy. Oblique imagery is not georeferenced and although these points are reported and enumerated, they are not mapped.

2.3 Identification and Quality Assurance

All bird and marine mammal species present in the images collected over Kaula Island were identified and quality assured using internal Normandeau processes.

All images containing birds and marine mammals were processed in each grid cell and then checked by Normandeau biologists. Normandeau's quality assurance manager is an experienced ornithologist and is responsible for maintaining and updating the image library, providing advice and guidance to the image analysis staff, and ensuring full quality control.

Known nesting habits of the booby species (*Sula*) such as nesting substrate and location were used to aid identification of juvenile birds in nests where the physical characteristics that aid identification were not visible. Masked and brown boobies (*Sula dactylatra* and *S. leucogaster*) are known to nest on the ground often near breezy cliff edges or other take-off features. Red-footed boobies (*S. sula*) usually nest on small trees or shrubs and have a larger nest platform.

2.4 Data Analysis and Enumeration

Each bird observation was classified as an adult, juvenile, or unknown. For clarity and continuity of reporting, nestlings were grouped with juveniles. For each observation, the following combination of associations were identified: none, nest, juvenile, 1 adult, or 2 adults. Dead birds are presented at the beginning of the results but are not included in any other analyses.

Enumeration of each species occurred at three different levels:

- 1) Minimum and estimated maximum abundance counts for each species using both vertical and oblique survey images.
- 2) An estimated number of nesting pairs of each species using both vertical and oblique survey images.
- 3) Minimum and maximum densities of each species based on raw counts from the vertical survey only. Oblique images were not georeferenced making the vertical areal coverage of imagery unquantifiable; therefore, calculation of the survey area effort is not possible from these images.

Raw counts for each age group (adult, juvenile, unknown) are presented for each species.

The estimated number of nesting pairs was calculated by adding the total number of adults with nests, juveniles with adult, juveniles with 2 adults, juveniles with nests, and unknown aged birds with nests.

Calculations for pair density were made using the same approach but included only birds recorded during the vertical survey divided by the total area in the survey grid (590,000 m²). As mentioned above, areal coverage calculations cannot be made from oblique imagery; therefore, oblique images are removed from this calculation.

Minimum densities were calculated for individuals recorded in the vertical surveys by dividing the raw counts of each species observed by the total area in the survey grid (590,000 m²). This follows the methodology used in Adams et al. (2022).

Maximum density calculations used the raw number of birds observed plus the following changes: adults with nests and unknown aged birds with a nest are multiplied by 2 to reflect the assumed other parent attending the nest; juveniles with nests are multiplied by 3 to include the juvenile and the assumed two adults attending the nest. This total was divided by the total area in the survey grid, thus presenting maximum abundance per m² as a density.

3 Results

3.1 Species Abundance

Thirteen marine mammals (one species) and 6,697 live birds (15 species) were recorded on Kaula Island during the July 28, 2025, survey (Table 3–1). Scientific names are provided in Table 3–1 and Appendix I. Boobies were the most frequently encountered species group, followed by terns and noddies, frigatebirds, tropicbirds and albatrosses, and scattered individuals of shearwaters and storm-petrels (Figure 3-1). Red-footed booby (n=1,417) was the most abundant bird species, and band-rumped storm-petrel (listed as endangered for the Hawaiian population [n=1]), which was recorded over water, was the least abundant species (Figure 3-2). Species abundance comparison with prior years is provided in Appendix III. Fifteen dead birds were observed during the surveys across four species: great frigatebird (n=1), red-footed booby (n=8), brown booby (n=1), masked booby (n=3), unidentified booby (n=1), and masked/red-footed booby (n=1) (Table 3–2). Latin names of all species can be found in Appendix I. Example images collected during the survey can be found in Appendix II.

Table 3–1. Number of Live Birds (in taxonomic order [Clements 2025]) and Marine Mammals Recorded on Kaula Island by Vertical and Oblique Surveys on July 28, 2025

Species/Group	Scientific	Number Recorded		
		Vertical	Oblique	Total
Birds				
Blue-billed White-Tern	<i>Gygis candida</i>	12	0	12
Brown Noddy	<i>Anous stolidus</i>	1,211	27	1,238
Black Noddy	<i>Anous minutus</i>	22	4	26
Sooty Tern	<i>Onychoprion fuscatus</i>	348	0	348

Species/Group	Scientific	Number Recorded		
		Vertical	Oblique	Total
Gray-backed Tern	<i>Onychoprion lunatus</i>	19	0	19
Unknown - Terns and Noddies		126	0	126
White-tailed Tropicbird	<i>Phaethon lepturus</i>	7	0	7
Red-tailed Tropicbird	<i>Phaethon rubricauda</i>	632	0	632
Tropicbird species	<i>Phaethon sp.</i>	17	0	17
Laysan Albatross	<i>Phoebastria immutabilis</i>	11	0	11
Black-footed Albatross	<i>Phoebastria nigripes</i>	10	0	10
Band-rumped Storm-Petrel**	<i>Hydrobates castro</i>	1	0	1
Christmas Shearwater	<i>Puffinus nativitatis</i>	3	0	3
Great Frigatebird	<i>Fregata minor</i>	711	0	711
Red-footed Booby	<i>Sula sula</i>	1,417	0	1,417
Brown Booby	<i>Sula leucogaster</i>	1,158	2	1,160
Masked Booby	<i>Sula dactylatra</i>	733	0	733
Booby species (Masked/Red-footed/Brown)	<i>Sula sp.</i>	81	0	81
Masked/Red-footed Booby	<i>Sula dactylatra/sula</i>	136	0	136
Masked/Brown Booby	<i>Sula dactylatra/leucogaster</i>	9	0	9
Total Birds		6,664	33	6,697
Marine Mammals				
Hawaiian Monk Seal**	<i>Neomonachus schauinslandi</i>	13	0	13
Total Birds and Marine Mammals		6,677	33	6,710

** Listed as Endangered and protected under the U.S. Endangered Species Act

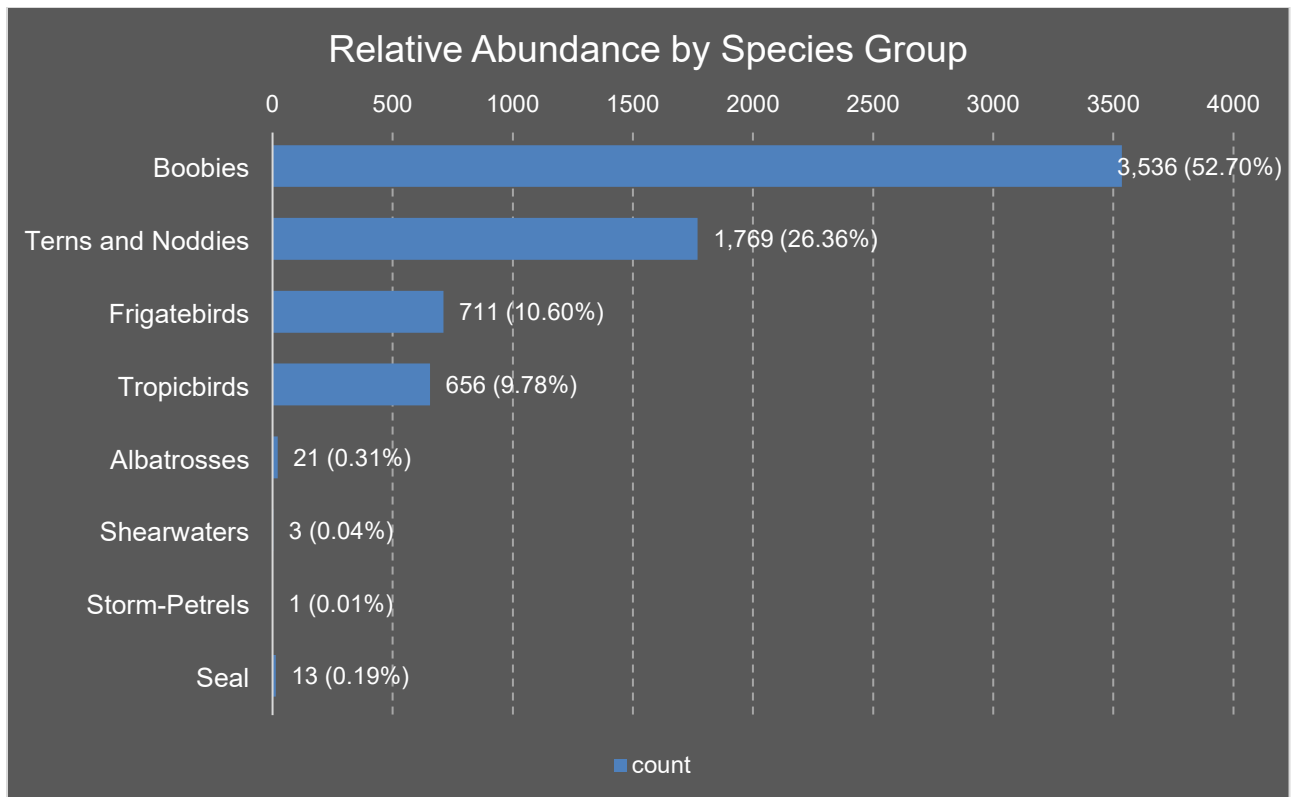


Figure 3-1. Relative abundance of species groups encountered in the July 2025 survey.

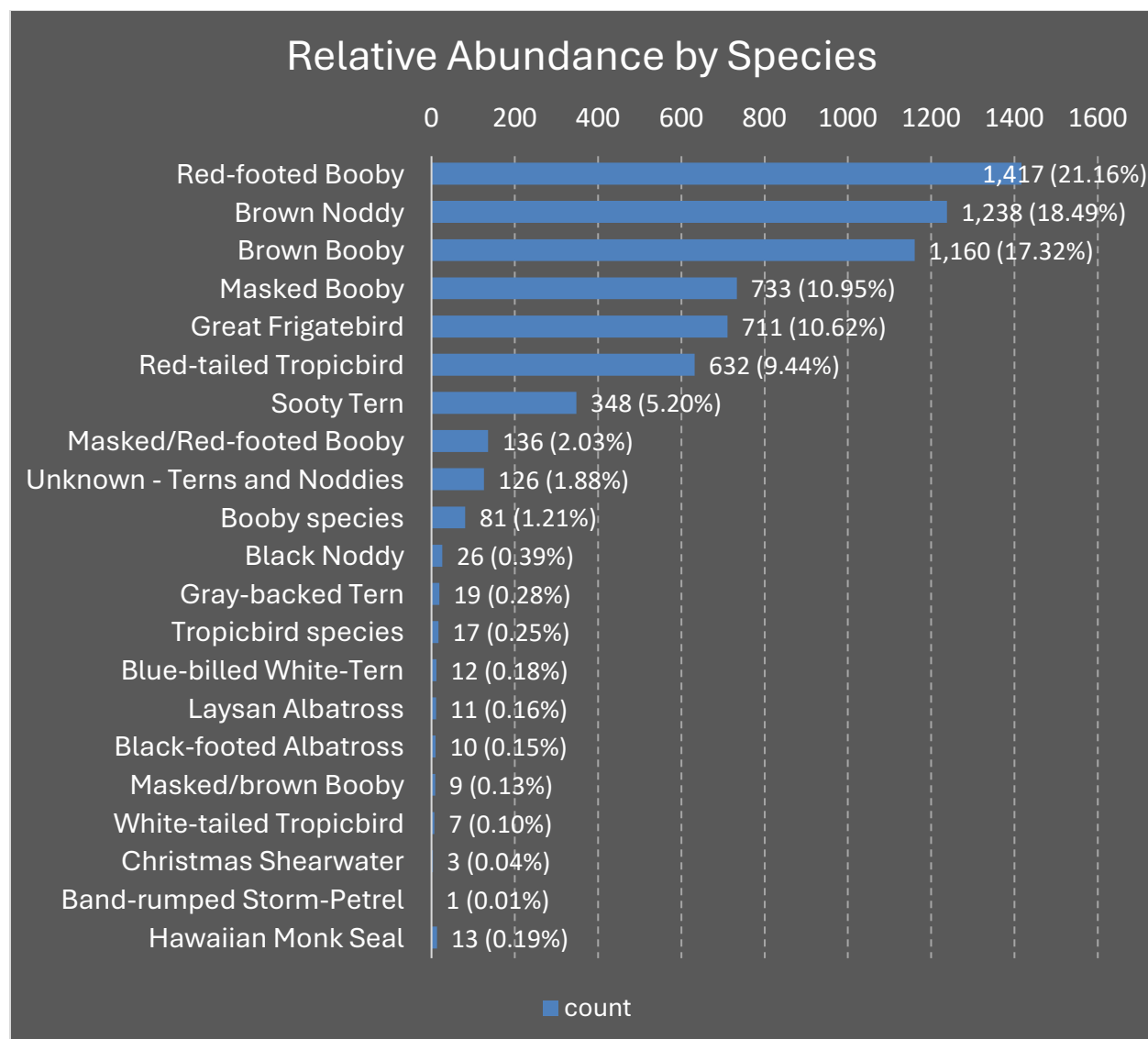


Figure 3-2. Relative abundance by species encountered in the July 2025 survey.

3.2 Species Distribution

3.2.1 Occurrence of Birds and Marine Mammals

Figure 3–3 shows the location of all birds and marine mammals recorded on Kaula Island during the July 2025 aerial survey, and Figure 3–4 through Figure 3–23 show the location of each species encountered. Although numbers of birds were sparser than previous years, patterns of distributions were similar. Birds were distributed throughout the island, but the western side of the island had fewer individuals than in previous years. Low numbers of brown noddies and sooty terns were found nearer cliff edges on the western side of the island. White-tailed and red-tailed tropicbirds and great frigatebirds were recorded mainly along the eastern concave section where Christmas shearwaters were also encountered. Albatrosses were mostly found in the northern part of the island with most of the black-footed albatrosses being on the northwest side,

and most of the Laysan albatrosses were on the northeastern side. Boobies were widely scattered with most of the population occurring along the northern central ridge. Masked boobies were primarily observed along the higher areas of the island while brown boobies and red-footed boobies were more widely distributed. Hawaiian monk seals were found on the ledges along the west side of the island, with one individual found on the east side of the island.

3.2.2 *Blue-billed White-Tern (new name following Clements [2025])*

A total of 12 blue-billed white-terns (10 sitting, 2 flying) were recorded during the survey (Table 3–1, Table 3–2). Sitting birds were found on the southeast slope of the island, on the central ridge, and on the west slope. Flying birds were found over water (Figure 3–4). All individuals were identified in the vertical imagery (Table 3–1).

3.2.3 *Brown Noddy*

A total of 1,238 brown noddies (1,076 flying, 162 sitting) were recorded during the survey (Table 3–1, Table 3–2), with virtually all flying birds found over water or near the coast all around the island; sitting birds were mostly along the western slopes near the cliff edges (Figure 3–5). Of the total recorded, 27 were identified in the oblique imagery and 1,211 in the vertical imagery (Table 3–1).

3.2.4 *Black Noddy*

Twenty-six black noddies (5 flying, 21 sitting) were recorded during the survey (Table 3–1, Table 3–2). Most birds were on the central western cliff edges of the island (Figure 3–6). Four of the birds were identified in the oblique imagery and 22 in the vertical imagery (Table 3–1).

3.2.5 *Sooty Tern*

A total of 348 sooty terns were recorded during the survey, all identified in the vertical survey (Table 3–1), of which 266 were flying and 82 were sitting (Table 3–2). The majority were in groups among the brown noddies on the west and south slope of the island (Figure 3–7).

3.2.6 *Grey-backed Tern*

Nineteen grey-backed terns (18 flying, 1 sitting) were recorded during the survey, all identified in the vertical imagery (Table 3–2, Table 3–1), most of which were recorded on the western side of the island (Figure 3–4).

3.2.7 *Unknown Terns and Noddies*

There were 126 individuals for which imagery was unclear that were ascribed to unknown terns and noddies (Table 3–1). Almost all were encountered on the west side of the island (Figure 3–8).

3.2.8 *White-tailed Tropicbird*

Seven white-tailed tropicbirds were recorded during the vertical survey (Table 3–1), all of which were sitting (Table 3–2). All were near the central ridge of the island (Figure 3–9).

3.2.9 Red-tailed Tropicbird

A total of 632 red-tailed tropicbirds were recorded during the vertical survey (Table 3–1) of which 527 were flying (Table 3–2). Most were found in the eastern concave section of the island (Figure 3–10) with fewer birds at the southern and northern ends.

3.2.10 Tropicbird species

For 17 individuals, imagery lacked identifying characteristics and these individuals were ascribed to tropicbird species (Table 3–1 and Figure 3–11).

3.2.11 Laysan Albatross

Eleven Laysan albatrosses were recorded during the vertical survey of which nine were sitting (Table 3–1, Table 3–2). Two were on the east slope of the island and the others were mostly on the central ridge and concave eastern slope (Figure 3–12).

3.2.12 Black-footed Albatross

Ten black-footed albatrosses were recorded during the vertical survey all of which were sitting (Table 3–1, Table 3–2). All were on the west slope of the island (Figure 3–12).

3.2.13 Band-rumped Storm-Petrel ** Endangered Species

A single band-rumped storm-petrel was recorded during the vertical survey flying over water off the northern tip of the island (Table 3–1, Table 3–2, Figure 3–13).

3.2.14 Christmas Shearwater

Three Christmas shearwater were identified in the imagery. All were flying; two over the concave east slope of the island and one offshore to the southwest of the island (Table 3–1, Figure 3–14).

3.2.15 Great Frigatebird

A total of 712 great frigatebirds were recorded in the vertical survey of which 603 were sitting and 1 was dead (Table 3–2). Most were present along the eastern side of the island in the concave section (Figure 3–15) with just a few birds present on the west side. There were 295 juveniles associated with nests (Table 3–2).

3.2.16 Red-footed Booby

A total of 1,425 red-footed boobies were recorded in the vertical survey of which 205 were in flight and 8 were dead (Table 3–2). Out of the 1,425 birds, 102 were identified as juveniles in nests (Table 3–2). They were present across the island, although there was higher density on the northeast slope of the island (Figure 3–16).

3.2.17 Brown Booby

A total of 1,161 brown boobies were recorded during the survey, of which 899 were sitting and one was dead (Table 3–2). They were widely distributed throughout the island but showed a preference for the eastern slope (Figure 3–17). Of the total of live birds recorded, two were found in the oblique imagery (Table 3–1).

3.2.18 Masked Booby

A total of 736 masked boobies were recorded in the vertical survey of which almost all (n=716) were sitting, and 3 were dead (Table 3–2). Most were along the highest ridge running through the center of the island and on the west slope toward the northern end of the island (Figure 3–18). Of the 733 live birds, 149 were immature (Table 3–2).

3.2.19 Booby Species Unknown (Masked/Red-footed/Brown)

Eighty-two unidentified boobies were recorded during the vertical survey (73 sitting, 1 dead) (Table 3–2). Most of these unidentified boobies were likely juveniles on nests with no adults in attendance (Table 3–2). There was no pattern of distribution for these individuals (Figure 3–19).

3.2.20 Masked Booby / Red-footed Booby

A total of 137 unidentified masked/red-footed boobies were recorded during the vertical survey (Table 3–1) of which 121 were sitting and one was dead (Table 3–2). Sixteen individuals were juvenile flying birds and 97 were juvenile sitting birds with no adults in attendance (Table 3–2). They were present across the island, although densities were lower in general on the southwest slope (Figure 3–20).

3.2.21 Masked Booby / Brown Booby

A total of nine unidentified masked/brown boobies were recorded during the survey, all of which were identified in the vertical survey (Table 3–1). Three were flying, and six were immature (Table 3–2). There was no discernable pattern of distribution (Figure 3–21).

3.2.22 Dead Birds

Fifteen dead birds representing four species were observed during the survey (Table 3–2): great frigatebird (n=1), red-footed booby (n=8), brown booby (n=1), masked booby (n=3), and the remaining 2 were an unidentified booby and a masked/red-footed booby. There was no pattern of distribution for dead individuals (Figure 3–22).

3.2.23 Hawaiian Monk Seal ** Endangered Species

A total of 13 adult Hawaiian monk seals were recorded, all but one individual were resting on nearshore ledges on the west side of the island, and one individual was on the southeast side of the island (Table 3–1, Figure 3–23).

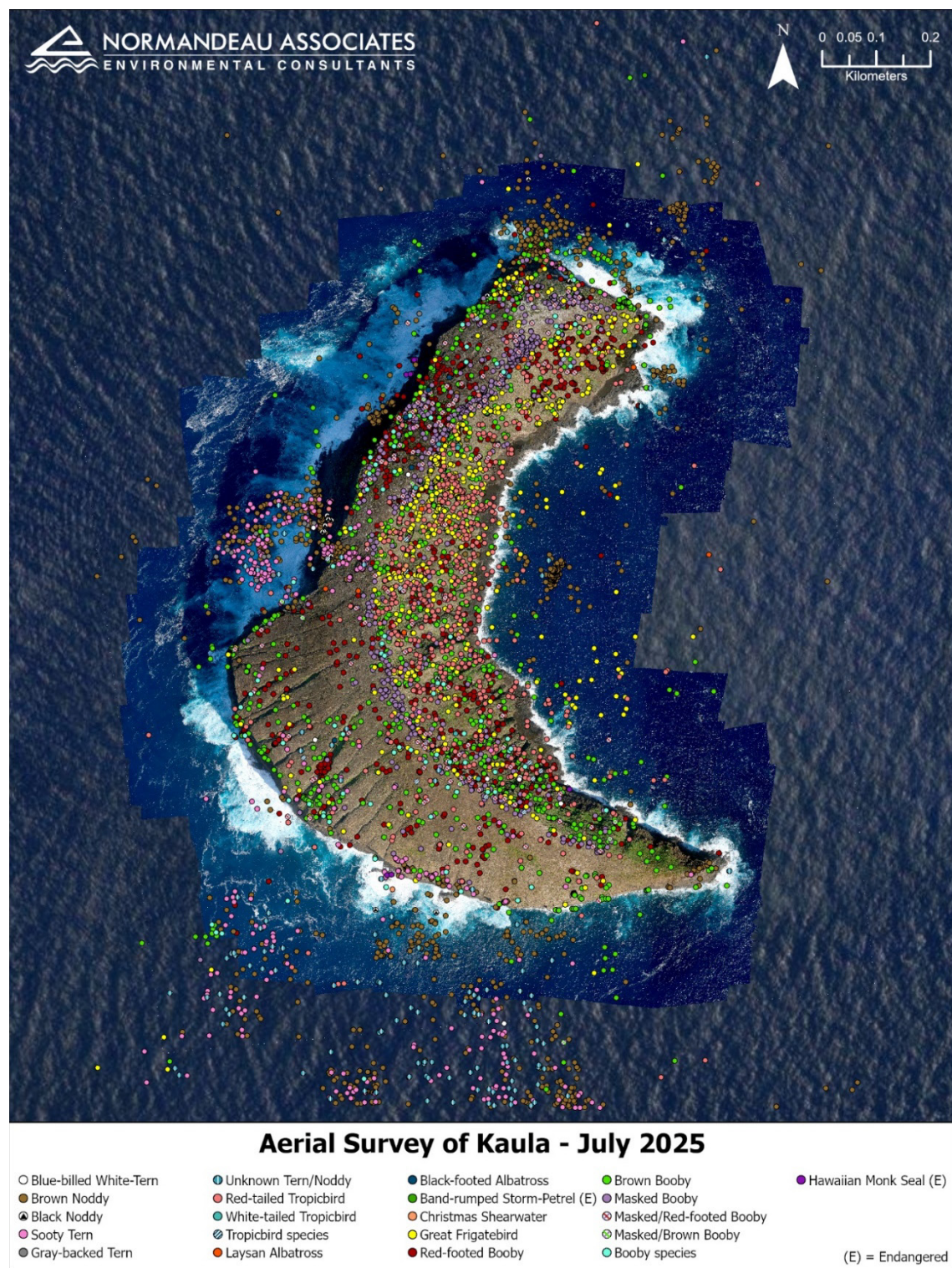


Figure 3-3. Distribution of all birds and marine mammals recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.

Table 3–2. Comparison of Species, Age-Class, and Numbers of Flying and Sitting Birds Recorded in August 2023 and July 2025 Aerial Surveys

Species/Group	August 2023							July 2025							
	Adult		Juvenile		Unknown		Total	Adult		Juvenile		Unknown		Dead	Total
	Flying	Sitting	Flying	Sitting	Flying	Sitting		Flying	Sitting	Flying	Sitting	Flying	Sitting		
Blue-billed White-Tern	—	—	—	—	—	—	0	2	9	—	1	—	—	—	12
Brown Noddy	3,433	6,221	152	187	666	375	11,034	801	129	2	12	273	21	—	1,238
Black Noddy	—	—	—	—	—	—	—	5	18	—	2	—	1	—	26
Sooty Tern	694	1,464	14	100	73	95	2,440	233	57	21	23	12	2	—	348
Gray-backed Tern	3	1	—	—	1	—	5	17	1	—	—	1	—	—	19
Unknown - Terns and Noddies	—	—	—	—	—	—	0	2	—	—	4	115	5	—	126
White-tailed Tropicbird	—	—	—	—	—	—	0	—	6	—	1	—	—	—	7
Red-tailed Tropicbird	163	35	—	6	—	2	206	524	81	3	24	—	—	—	632
Tropicbird species	—	—	—	—	—	—	0	—	7	—	6	—	4	—	17
Laysan Albatross	2	—	1	—	—	—	3	2	7	—	2	—	—	—	11
Black-footed Albatross	—	—	—	—	—	—	0	—	5	—	5	—	—	—	10
Band-rumped Storm-Petrel	—	—	—	—	—	—	0	1	—	—	—	—	—	—	1
Christmas Shearwater	—	—	—	—	—	—	0	2	—	—	—	1	—	—	3
Great Frigatebird	55	184	4	133	1	—	377	102	291	4	295	3	17	1	712
Red-footed Booby	383	882	32	69	—	3	1,369	187	1,117	17	102	1	1	8	1,425
Brown Booby	235	852	2	72	6	21	1,188	259	816	—	78	3	5	1	1,161
Masked Booby	18	630	16	74	—	1	739	12	561	7	142	1	13	3	736
Booby-species unknown	—	—	2	4	—	1	7	—	—	5	21	4	52	1	82
Masked/Red-footed Booby	3	74	23	121	—	7	228	—	20	16	97	—	4	1	137
Masked/Brown Booby	—	2	1	8	4	27	42	—	1	3	3	—	2	—	9
Total	4,989	10,345	247	774	751	532	17,638	2,149	3,126	78	818	414	140	15	6,712

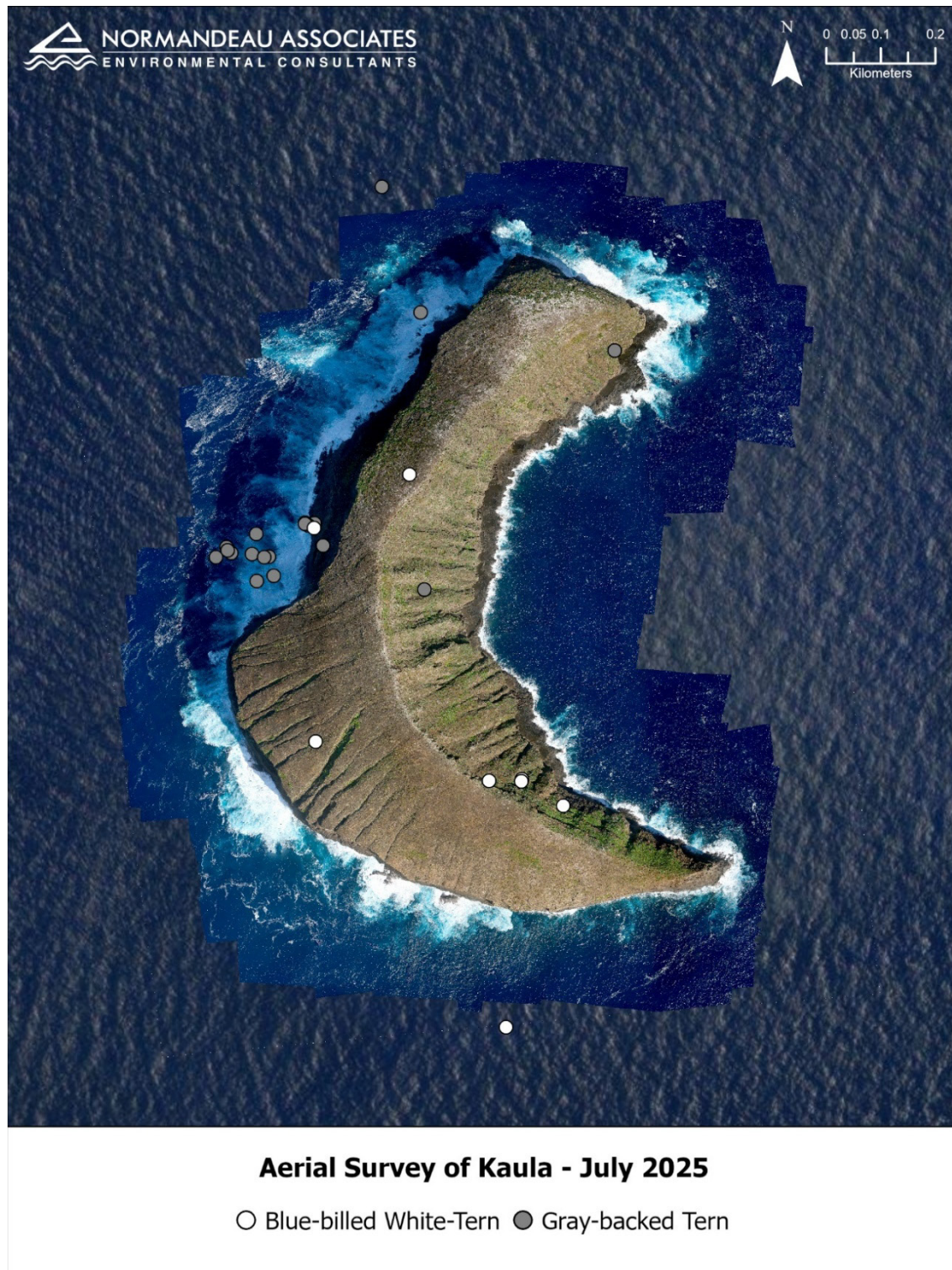


Figure 3-4. Distribution of blue-billed white-tern and grey-backed tern recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-5. Distribution of brown noddy recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-6. Distribution of black noddy recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.

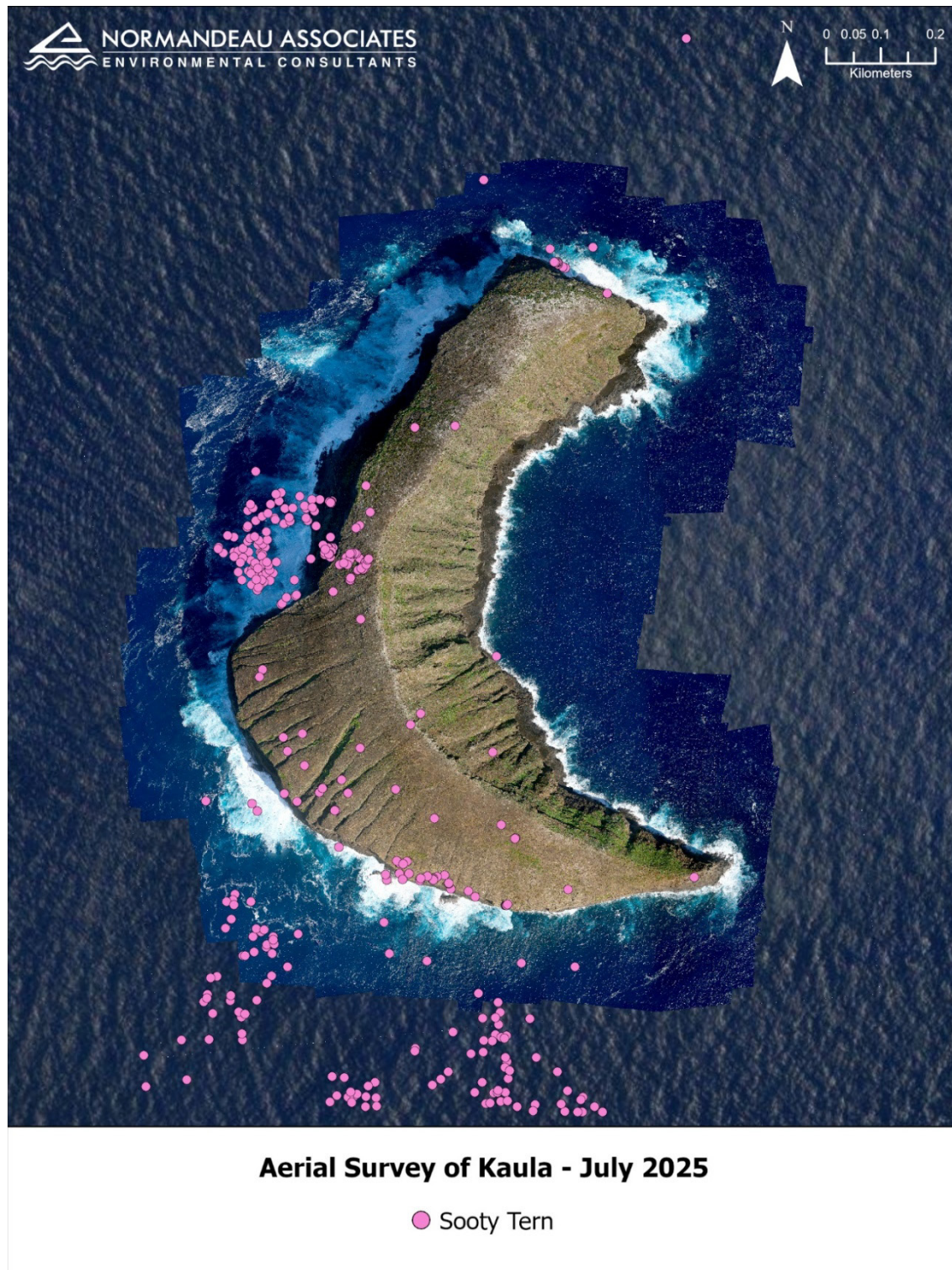


Figure 3-7. Distribution of sooty tern recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-8. Distribution of unknown tern/noddy recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-9. Distribution of white-tailed tropicbird recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.



Figure 3-10. Distribution of red-tailed tropicbird recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-11. Distribution of unidentified tropicbird recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-12. Distribution of Laysan and black-footed albatross recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-13. Distribution of band-rumped storm-petrel recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-14. Distribution of Christmas shearwater recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.

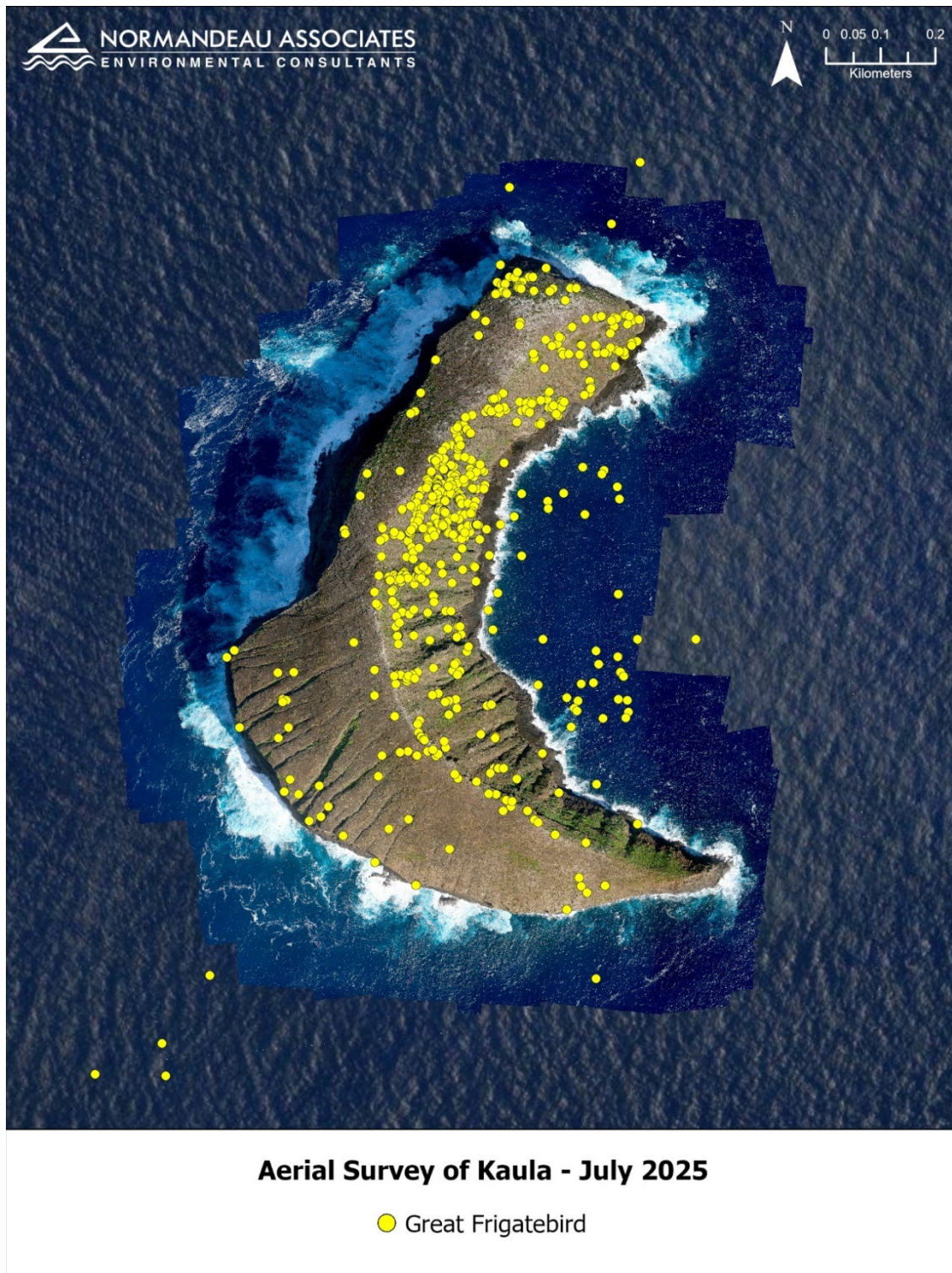


Figure 3-15. Distribution of great frigatebird recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.

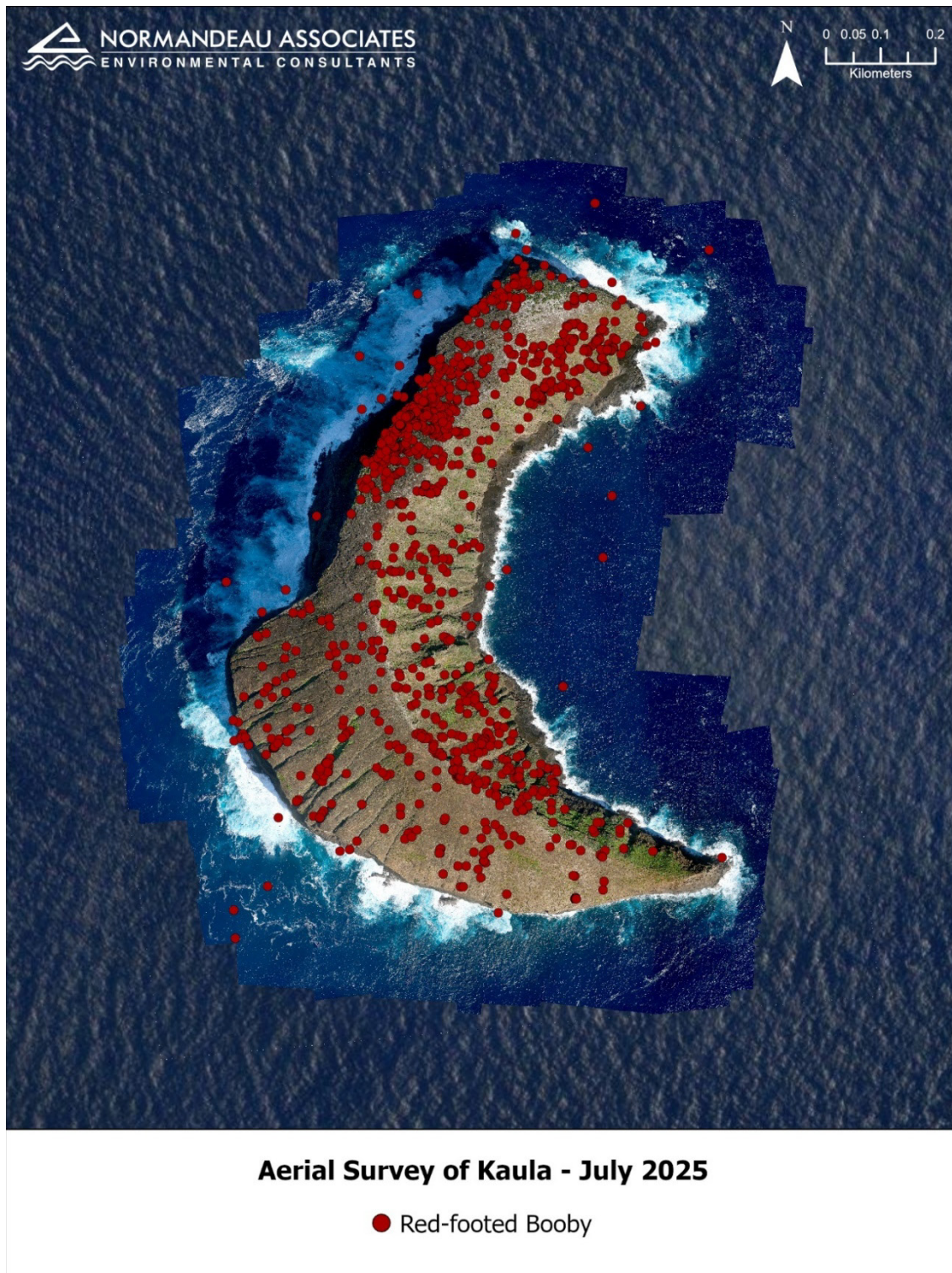


Figure 3-16. Distribution of red-footed booby recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.

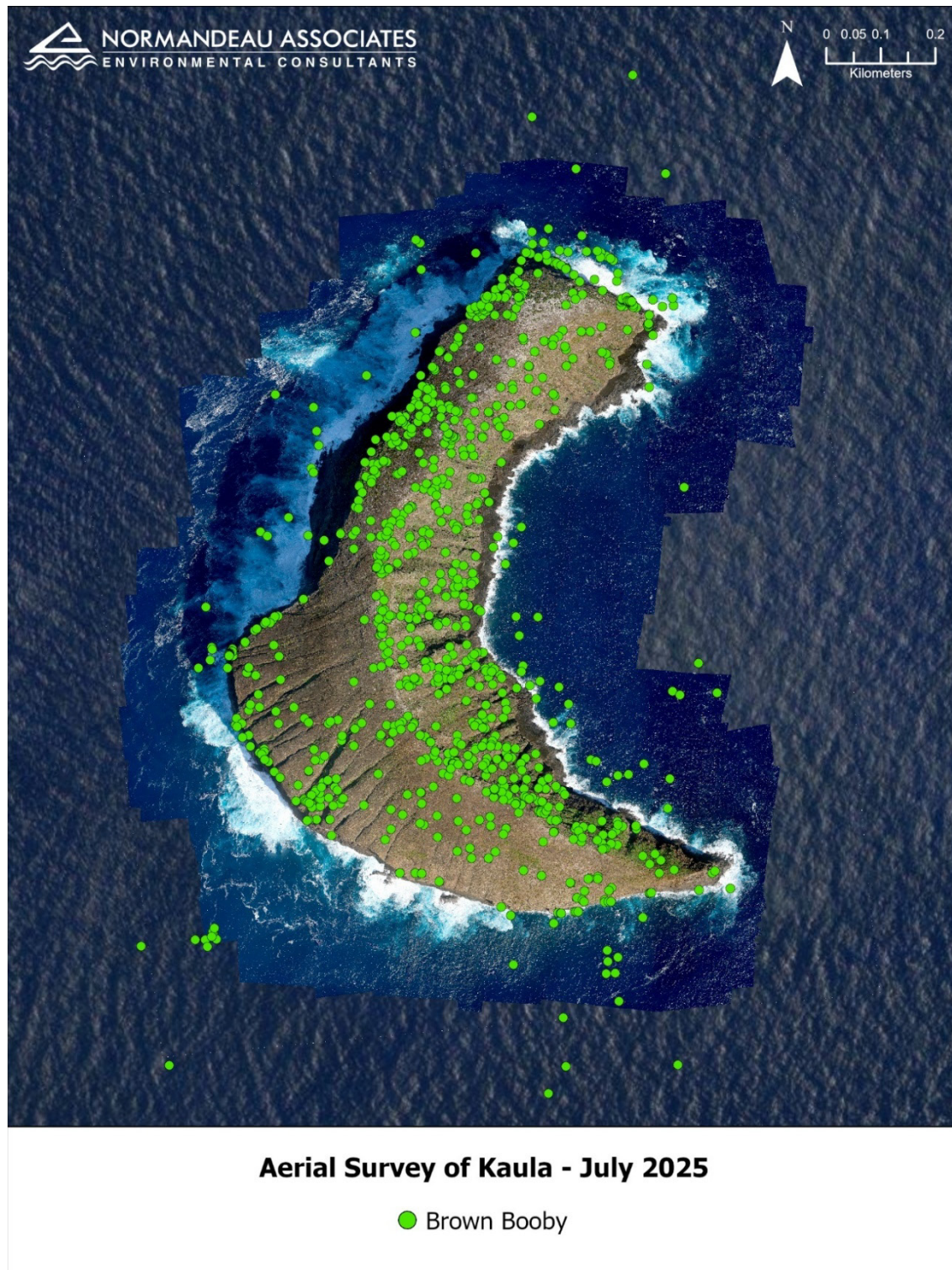


Figure 3-17. Distribution of brown booby recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-18. Distribution of masked booby recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-19. Distribution of booby species unknown (Masked/Red-footed/Brown) recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-20. Distribution of masked/red-footed booby recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-21. Distribution of masked/brown booby recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap. Points over water are flying birds.



Figure 3-22. Distribution of dead birds recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.



Figure 3-23. Distribution of Hawaiian monk seals recorded on Kaula Island during the July 2025 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

4 Discussion

During the July 28, 2025, vertical and oblique surveys, 6,697 live birds, 15 dead birds, and 13 Hawaiian monk seals were recorded at Kaula Island (Table 3–1, Table 3–2). The fifteen bird species present were blue-billed white-tern, brown noddy, black noddy, sooty tern, gray-backed tern, white-tailed tropicbird, red-tailed tropicbird, Laysan albatross, black-footed albatross, band-rumped storm-petrel (listed as Endangered and protected under the U.S. Endangered Species Act), Christmas shearwater, great frigatebird, red-footed booby, brown booby, and masked booby. The most abundant species recorded was red-footed booby, accounting for 21.2% ($n=1,425$) of seabirds, closely followed by brown noddy representing 18.4% ($n=1,238$) and brown booby representing 17.3% ($n=1,161$) (Table 3–2). Masked booby and great frigatebird represented 11% and 10.6% of encountered individuals ($n=736$ and $n=712$, respectively) (Table 3–2). Red-tailed tropicbird and sooty tern were other abundant species with red-tailed tropicbird representing 9.4% of the sample ($n=632$) and sooty tern representing 5.2% of the sample ($n=348$) (Table 3–2). Each of the remaining identified species represent $<1\%$ of the birds encountered.

In this survey, the relative abundance (most numerous to least numerous) is similar to the July 2021 survey results, but the overall abundance for 2025 is lower than that of 2021 (Appendix III) and significantly lower than the August 2023 survey (Table 3–2). In this report we have added density per m^2 estimate comparisons to the survey conducted in August 2023 (Appendix V).

Seabirds can spend long periods at sea so single birds recorded during this survey may be half of a pair. Appendix IV shows the minimum estimated number of birds present based on the actual individuals recorded in the imagery and a maximum estimated number of birds derived from potential for being half of a pair. However, given that seabirds in Hawaii breed year-round, it is possible that not all birds paired up in July.

When comparing the results of the July 28, 2025 and August 3, 2023 surveys, the difference in numbers of terns and noddies is dramatic. The most abundant species during the 2023 survey was brown noddy (maximum 0.029968 per m^2) (Appendix V), which had an estimated 6,562 breeding pairs found concentrated along the western slopes and cliffs. Sooty terns (maximum 0.007003 per m^2) (Appendix V), which were often collocated with brown noddies, had an estimated 1,626 breeding pairs in 2023. In the 2025 survey, maximum brown noddy density was an order of magnitude lower at 0.00228305 per m^2 (Appendix V) with an estimated 114 breeding pairs (Appendix IV), and maximum sooty tern density was 0.00070678 per m^2 (Appendix V) with an estimated 60 breeding pairs (Appendix IV). Density estimates could not be generated in 2021; however, when comparing numbers of brown noddy individuals, 1,238 individuals were recorded in 2025 compared to 11,034 recorded in 2023 and 3,456 in 2021. These interannual fluctuations suggest that the timing of nesting may vary each year and potentially be responsible for the apparent decrease in numbers of noddies encountered. A review of weather conditions for two months prior to the 2025 survey found no extreme events except for some elevated trade winds.

Red-footed booby was the most frequently encountered species in the July 2025 survey ($n=1,414$) (Table 3–2) with a maximum density of 0.00423559 per m^2 , which is similar to the August 2023 survey density (0.003892 per m^2) (Appendix V), but a lower number of individuals than encountered in the July 2021 survey ($n=6,016$); Appendix VII). Black noddies were found

on site (last positively identified in August 2013) with 26 individuals found mostly in the western cliff edges of the island (Appendix III).

Great frigatebirds were distributed mostly in the concave east slope of the island (Figure 3–15). This follows the same pattern recorded in previous aerial digital surveys. Numbers ($n=711$) were higher than those recorded in August 2023 ($n=377$) but lower than July 2021 ($n=1,375$; Appendix VII). The reported great frigatebird numbers from July 2021 were the highest since the very first aerial digital survey (April 2013). Numbers recorded from aerial digital surveys have generally been much higher than those recorded in previous boat-based surveys. Boat-based surveys conducted between July 2009 and July 2012 averaged less than 200 frigatebirds per survey (Appendix III). The maximum density for great frigatebird in July 2025 was 0.00258136 per m^2 (Appendix V) with an estimated 546 breeding pairs (Appendix IV).

Red-tailed tropicbirds numbers recorded in this survey ($n=632$) were higher than those recorded in August 2023 ($n=206$) and July 2021 ($n=125$) (Appendix VII). Maximum red-tailed tropicbird density was estimated to be 0.00121017 per m^2 (Appendix V) with an estimated 78 breeding pairs (Appendix IV).

Brown booby numbers ($n=1,160$) were similar to those in August 2023 ($n=1,188$) and lower than July 2021 ($n=1,573$; Table 3–2, Appendix III). Maximum density for brown booby in July 2025 was 0.00307288 per m^2 (Appendix V) with an estimated 714 breeding pairs (Appendix IV).

Masked boobies were distributed mainly along the elevated central ridge; results of this survey appeared similar to those of previous aerial digital surveys with very few birds in the southwestern section (Figure 3–18). The total of 733 birds is almost identical to the August 2023 survey, which recorded 739 (Appendix III). The July 2025 estimate for breeding pairs is 633 (Appendix IV). The species is known to lay eggs between January and July (Richardson 1957; Nelson 1978). The three largest counts of masked booby have occurred in either August or September on Kaula (Appendix III), and the August 2023 low count was ascribed to the extended bad weather pattern in 2023 that potentially affected breeding success. This year's count has no prior extreme weather patterns identified, and low numbers might be a result of the survey potentially missing peak breeding effort or represent declining numbers of this species on the island.

A visual comparison of part of the site between July 2025 and August 2023 shows the lower density of apparently occupied nests for all species, particularly brown noddies (Appendix VI).

Hawaiian monk seals are endangered and protected under the U.S. Endangered Species Act, the U.S. Marine Mammal Protection Act, Hawaii State Senate Bill 2441, Hawaii Revised Statutes Chapter 195D, Hawaii Administrative Rules 13-124 and are classed by IUCN as category D1 (Vulnerable). Of the 13 Hawaiian monk seals recorded, 12 were on the west side of the island and one was recorded on the east side (Figure 3–23). Numbers have remained fairly consistent over the 11 aerial digital surveys between 2013 and 2025, although this is the highest number recorded during a single survey and matching the August 2023 survey (Appendix VII).

Aerial surveys provide a method for obtaining complete seabird counts and are particularly effective at accurately assessing the number of birds on aboveground nests, a task that would be

almost impossible from a boat. Aerial imagery also creates a permanent record/snapshot of the area at a specific time, allowing users to revisit the imagery/data as often as required. It is important to note that seabird survey techniques for Kaula Island have differed historically, and the results may not be directly comparable (see Appendix III for a list of all bird species previously observed and survey type).

5 References

- Adams J, Kelsey EC, Stenske J, Felis JJ. 2022. Aerial counts for surface-nesting seabirds at Lehua Island and Moku Manu Islet and Ulupa‘u Crater, O‘ahu, in 2019: U.S. Geological Survey Data Report 1161, 20 p., [https://doi.org/ 10.3133/ dr1161](https://doi.org/10.3133/dr1161).
- Clements JF, Rasmussen PC, Schulenberg TS, Iliff MJ, Gerbracht JA, Lepage D, Spencer A, Billerman SM, Sullivan BL, Smith M, Wood CL. 2025. The eBird/Clements checklist of Birds of the World: v2025. Downloaded from <https://www.birds.cornell.edu/clementschecklist/download/>
- del Hoyo J, Elliott A, Sargatal J. 1992. Handbook of the Birds of the World. Vol. 1: Ostrich to Ducks. Lynx Edicions, Barcelona.
- DON. 2008. Hawaii Range Complex FEIS/OEIS. Department of Navy, Commander Fleet Air Hawaii.
- DON. 2009. Kaula Island Seabird Monitoring Plan. Department of Navy, Commander Fleet Air Hawaii.
- DON. 2011. Kaula / Kauai field report, HRC marine species monitoring, February 15–20, 2011. Prepared for Commander Pacific Fleet by NAVFAC Pacific.
- DON. 2013. Hawaii-Southern California Training and Testing EIS/OEIS. Department of Navy, Commander Fleet Air Hawaii.
- Elmer JS, Swedberg G. 1971. Assessment of environmental impact, Kaula Island target. DON, Commander Fleet Air Hawaii.
- Fujimoto J, Juola F. 2012. *Kaula Island ship-based seabird survey, 6 July 2012*. Prepared for Commander Pacific Fleet by NAVFAC Pacific.
- Nelson JB. 1978. The Sulidae, gannets and boobies. Oxford, U.K: Oxford University Press.
- Normandeau Associates and Air Data Solutions. 2023. Aerial Survey of Seabirds and Marine Mammals at Kaula Island, Hawaii, August 2023. Prepared for Commander, Pacific Fleet through a contract with NAVFAC Pacific.
- Palmer HS. 1936. Geology of Lehua and Kaula islands. Bernice P. *Bishop Museum Occasional Papers* 12(13). (Referenced in Pepi et al. 2009)
- Pepi VE, Kumar A, Laut ME, Hallman J, Kim J, Anders AD. 2009. *Kaula Island ship-based seabird and marine mammal surveys, 21-22 July 2009*. Prepared for Commander, Pacific Fleet by NAVFAC Pacific.
- Richardson F. 1957. The Breeding Cycles of Hawaiian Sea Birds. Bernice P. *Bishop Museum Bulletin* No. 218. Honolulu.

6 Appendices

Appendix I. Scientific Names of Relevant Bird and Mammal Species

Common Name	Scientific Name
Blue-billed White-Tern	<i>Gygis candida</i>
Brown Noddy	<i>Anous stolidus</i>
Black Noddy	<i>Anous minutus</i>
Sooty Tern	<i>Onychoprion fuscatus</i>
Gray-backed Tern	<i>Onychoprion lunatus</i>
Unknown - Terns and Noddies	
White-tailed Tropicbird	<i>Phaethon lepturus</i>
Red-tailed Tropicbird	<i>Phaethon rubricauda</i>
Tropicbird species	<i>Phaethon sp.</i>
Laysan Albatross	<i>Phoebastria immutabilis</i>
Black-footed Albatross	<i>Phoebastria nigripes</i>
Band-rumped Storm-Petrel	<i>Hydrobates castro</i>
Christmas Shearwater	<i>Puffinus nativitatis</i>
Great Frigatebird	<i>Fregata minor</i>
Red-footed Booby	<i>Sula sula</i>
Brown Booby	<i>Sula leucogaster</i>
Masked Booby	<i>Sula dactylatra</i>
Booby species (Masked/Red-footed/Brown)	<i>Sula sp.</i>
Masked/Red-footed Booby	<i>Sula dactylatra/sula</i>
Masked/Brown Booby	<i>Sula dactylatra/leucogaster</i>
Hawaiian Monk Seal	<i>Neomonachus schauinslandi</i>

Appendix II. Survey Imagery: Vertical Image Examples.

Note: Image resolution is reduced in this format



Figure 6-1. White-tailed tropicbird during the July 2025 survey.



Figure 6-2. Red-tailed tropicbird during the July 2025 survey.



Figure 6-3. Laysan albatross during the July 2025 survey.



Figure 6-4. Christmas shearwater during the July 2025 survey.



Figure 6-5. Great frigatebird during the July 2025 survey.



Figure 6-6. Red-footed booby during the July 2025 survey.



Figure 6-7. Brown booby during the July 2025 survey.



Figure 6-8. Masked booby during the July 2025 survey.



Figure 6-9. Hawaiian monk seals resting on ledges during the July 2025 survey.

Appendix III. Results of Bird Surveys Conducted on Kaula Island, Hawaii (1932–2025)*

Common Name Scientific Name	Land-Based Survey (A)											Boat-Based Survey (A, B, C)				Aerial Digital Survey (D)													
	8/32	8/71	1/76	9/76	3/78	8/78	3/79	6/80	4/84	6/93	11/98	7/09 (B)	6/10 (A)	7/11 (C)	7/12 (C)	4/13	8/13	1/14	1/15	7/15	3/16	7/17	8/18	11/19	7/21	8/23	7/25		
Pacific Golden Plover <i>Pluvialis fulva</i>	Several	–	10	14	–	1	2	–	21	–	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Wandering Tattler <i>Tringa incana</i>	–	–	5	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Ruddy Turnstone <i>Arenaria interpres</i>	–	50	5	20	–	4	24	1	7	1	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Blue-billed White-Tern <i>Gygis candida</i>	uncommon	10	10	200	40	10	–	9	12	9	–	10	9	9	12	6	–	–	–	1	–	–	–	–	–	–	–	12	
Brown Noddy <i>Anous stolidus</i>	most numerous	67,700	–	7,000	7,000	10,000	1,000	10,560	3,950	5,778	–	–	–	–	–	57	3,713	–	–	7,137	4,115	7,871	7,612	–	3,456	11,034	1,238	–	
Black Noddy <i>Anous minutus</i>	–	100	20	100	75	200	–	–	207	6	–	–	–	–	–	–	22	–	–	–	–	–	–	–	–	–	–	26	
Brown/Black Noddy <i>Anous stolidus/minutus</i>	–	–	–	–	–	–	–	–	–	–	–	711	705	306	597	–	–	–	–	–	–	–	–	–	–	–	–	–	
Blue-gray Noddy <i>Anous ceruleus</i>	small colony	–	–	200	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Sooty Tern <i>Onychoprion fuscatus</i>	common	16,800	2,500	1,000	130,000	2,500	50,000	28,850	83,680	27,255	200	6,169	3,382	9,745	4,509	14,635	7	–	–	147	40,814	768	6,535	–	2,523	2,440	348	–	
Gray-backed Tern <i>Onychoprion lunatus</i>	uncommon	2,800	–	250	1,250	50	300	4,110	1,467	35	–	1	3	–	–	4	–	–	–	–	1	–	5	–	–	5	19	–	
Unknown - Terns and Noddies	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	126	
White-tailed Tropicbird <i>Phaethon lepturus</i>	–	3	1	1	–	1	2	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	
Red-tailed Tropicbird <i>Phaethon rubricauda</i>	common	950	–	450	60	100	40	276	209	146	15	31	3	5	1	314	85	–	1	100	23	502	245	1	125	206	632	–	
Tropicbird species <i>Phaethon</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17	
Laysan Albatross <i>Phoebastria immutabilis</i>	–	1 old egg	150	–	100	–	100	9	33	44	60	–	–	–	–	20	11	81	100	–	21	–	–	17	–	3	11	–	
Black-footed Albatross <i>Phoebastria nigripes</i>	1 old egg	–	100	–	75	–	75	–	2	4	10	–	–	–	–	3	–	11	3	–	4	–	–	–	–	–	–	10	
Band-rumped Storm-Petrel <i>Hydrobates castro</i>	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	
Bonin Petrel <i>Pterodroma hypoleuca</i>	1 chick	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Bulwer's Petrel <i>Bulweria bulwerii</i>	several	100	–	100	–	50	–	100	580	100	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Wedge-tailed Shearwater <i>Ardenna pacifica</i>	Many burrows	4,100	–	4,000	–	800	–	1,415	980	400	200	16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Christmas Shearwater <i>Puffinus nativitatis</i>	–	450	–	250	–	100	25	20	60	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	
Great Frigatebird <i>Fregata minor</i>	common	950	250	800	400	250	250	134	155	701	650	131	430	105	26	1,415	1,369	621	748	1,078	1,005	777	719	316	1,375	377	711	–	
Red-footed Booby <i>Sula sula</i>	uncommon	1,300	100	150	85	200	400	344	222	1,375	1,200	–	–	–	–	1,690	191	98	209	3,693	1,319	2,650	4,764	1,196	6,016	1,369	1,417	–	

Aerial Survey of Seabirds and Marine Mammals at Kaula Island, Hawaii, July 2025

Common Name Scientific Name	Land-Based Survey (A)											Boat-Based Survey (A, B, C)				Aerial Digital Survey (D)												
	8/32	8/71	1/76	9/76	3/78	8/78	3/79	6/80	4/84	6/93	11/98	7/09 (B)	6/10 (A)	7/11 (C)	7/12 (C)	4/13	8/13	1/14	1/15	7/15	3/16	7/17	8/18	11/19	7/21	8/23	7/25	
Brown Booby <i>Sula leucogaster</i>	common	1,700	50	1,000	75	60	200	212	169	397	60	112	1	6	40	101	109	3	2	867	179	969	1,231	185	1,573	1,188	1,160	
Masked Booby <i>Sula dactylatra</i>	common	1,000	300	1,200	125	200	400	236	202	567	350	–	–	–	–	550	219	65	84	526	183	514	1,312	217	1,262	739	733	
Booby species (Masked/Red-footed/Brown) <i>Sula</i> sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	713	159	184	7	81	
Masked/Red-footed Booby <i>Sula dactylatra</i> / <i>S. sula</i>	–	–	–	–	–	–	–	–	–	–	–	820	850	1,859	912	–	–	–	–	27	–	24	–	–	–	228	136	
Masked/Brown Booby <i>Sula dactylatra</i> / <i>S. leucogaster</i>	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	51	–	–	42	9	
American Barn Owl <i>Tyto furcata</i>	–	1	3	3	–	1	6	4	2	7	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Warbling White-eye <i>Zosterops japonicus</i>	–	–	2	3	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Northern Mockingbird <i>Mimus polyglottos</i>	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Scaly-breasted Munia <i>Lonchura punctulata</i>	–	–	–	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
House Finch <i>Haemorhous mexicanus</i>	–	6	15	40	–	20	6	–	1	1	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Northern Cardinal <i>Cardinalis cardinalis</i>	–	2	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Total Estimated Number of Birds	–	98,022	3,521	16,811	139,285	14,548	52,831	46,280	91,959	36,847	2,785	8,001	5,385	12,035	6,097	18,795	5,733	879	1,145	13,576	47,664	14,075	23,187	2,091	16,514	17,638	6,697	
Total Number of Species	16	19	16	24	12	19	17	15	19	19	15	11	11	8	8	11	9	6	7	8	10	7	8	7	8	9	15	

*Data presented in taxonomic order following Clements (2025) and data sourced from:

- A DON. 2011. Kaula / Kaua'i field report, HRC marine species monitoring, February 15-20, 2011. Prepared for Commander Pacific Fleet by NAVFAC Pacific.
- B Pepi, V. E., A. Kumar, M. E. Laut, J. Hallman, J. Kim, and A. D. Anders. 2009. *Kaula Island ship-based seabird and marine mammal surveys, 21-22 July 2009*. Prepared for Commander, Pacific Fleet by NAVFAC Pacific.
- C Fujimoto, J. & Juola, F. 2012. *Kaula Island ship-based seabird survey, 6 July 2012*. Prepared for Commander, Pacific Fleet by NAVFAC Pacific.
- D Normandeau Associates and Air Data Solutions. 2023. Aerial Survey of Seabirds and Marine Mammals at Kaula Island, Hawaii, August 2023. Prepared for Commander, Pacific Fleet through a contract with NAVFAC Pacific.

Appendix IV. Estimates of Seabird Numbers and Estimated Pairs During the July 2025 Aerial Digital Survey of Kaula Island, Hawaii

Species/Group	Minimum Abundance ¹	Maximum Abundance ²	Estimated Pairs ³
Blue-billed White-Tern	10	13	5
Brown Noddy	1,236	1,347	114
Black Noddy	24	37	13
Sooty Tern	342	417	60
Gray-backed Tern	19	20	1
Unknown - Terns and Noddies	126	138	8
White-tailed Tropicbird	7	15	7
Red-tailed Tropicbird	631	714	78
Tropicbird species	17	36	15
Laysan Albatross	11	22	9
Black-footed Albatross	8	18	6
Band-rumped Storm-Petrel	1	1	0
Christmas Shearwater	3	3	0
Great Frigatebird	710	1,523	546
Red-footed Booby	1,413	2,499	1,091
Brown Booby	1,161	1,813	714
Masked Booby	747	1,449	633
Booby species (Masked/Red-footed/Brown)	83	172	68
Masked/Red-footed Booby	134	344	114
Masked/Brown Booby	9	18	6

1 Minimum abundance is the raw number of birds observed.

2 Maximum abundance is the raw number of birds observed plus the following changes: adults with nests and unknown aged birds with a nest are multiplied by 2 to reflect the other parent attending the nest; juveniles with nests are multiplied by 3 to include the juvenile and the assumed two adults that are attending the nest

3 Estimated pairs are calculated by adding the adults with nests, juveniles with adult, juveniles with 2 adults, juveniles with nets and unknown aged birds with nests

Appendix V: Comparison of Estimated Density (per m²) of Seabirds August 2023 and July 2025 Using Vertical Imagery Only

Density was calculated by dividing the number of each species observed in the vertical surveys by the georeferenced vertical survey area (590,000 m²)

Species	2023			2025		
	Minimum Density	Maximum Density	Estimated Pair Density	Minimum Density	Maximum Density	Estimated Pair Density
Blue-billed White-Tern				0.00001695	0.00002203	0.00000847
Brown Noddy	0.018685	0.029968	0.011107	0.00209492	0.00228305	0.00019322
Black Noddy				0.00004068	0.00006271	0.00002203
Sooty Tern	0.004136	0.007003	0.002756	0.00057966	0.00070678	0.00010169
Gray-backed Tern	0.000008	0.00001	0.000002	0.00003220	0.00003390	0.00000169
Unknown - Terns and Noddies				0.00021356	0.00023390	0.00001356
White-tailed Tropicbird				0.00001186	0.00002542	0.00001186
Red-tailed Tropicbird	0.000349	0.000429	0.000069	0.00106949	0.00121017	0.00013220
Tropicbird species				0.00002881	0.00006102	0.00002542
Laysan Albatross	0.000005	0.000005	0	0.00001864	0.00003729	0.00001525
Black-footed Albatross				0.00001356	0.00003051	0.00001017
Band-rumped Storm-Petrel				0.00000169	0.00000169	0.00000000
Christmas Shearwater				0.00000508	0.00000508	0.00000000
Great Frigatebird	0.000632	0.001363	0.00052	0.00120339	0.00258136	0.00092542
Red-footed Booby	0.00231	0.003892	0.001507	0.00239492	0.00423559	0.00184915
Brown Booby	0.001864	0.003336	0.00141	0.00196780	0.00307288	0.00121017
Masked Booby	0.001251	0.002468	0.001146	0.00126610	0.00245593	0.00107288
Booby species (Masked/Red-footed/Brown)	0.000012	0.000027	0.000008	0.00014068	0.00029153	0.00011525
Masked/Red-footed Booby	0.000347	0.000853	0.000302	0.00022712	0.00058305	0.00019322
Masked/Brown Booby	0.000069	0.000141	0.000061	0.00001525	0.00003051	0.00001017

Appendix VI. Survey Imagery: Density Comparison Image Examples

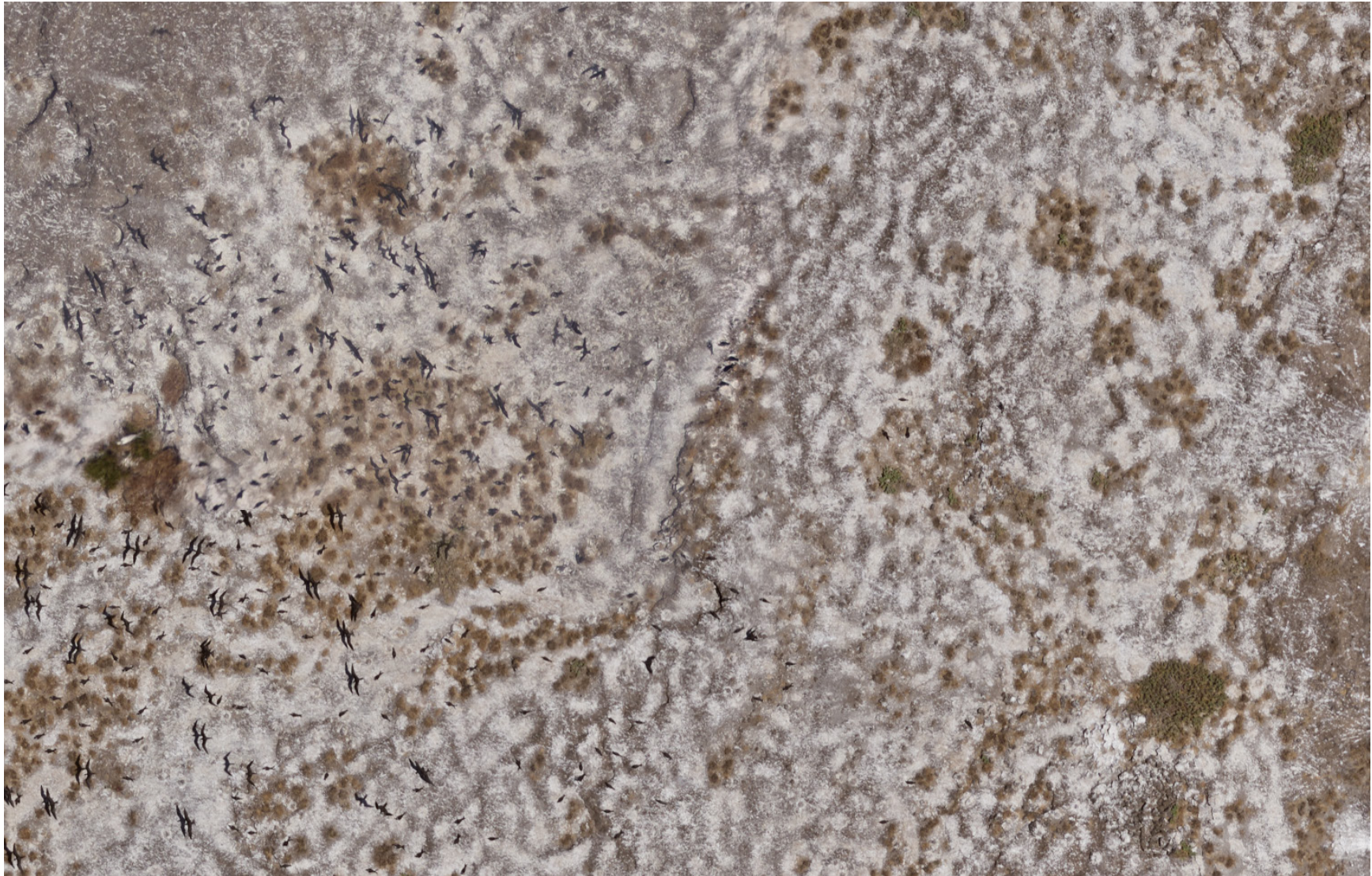


Figure 6-10. Area with brown noddies during the August 2023 survey.



Figure 6-11. Same location during the July 2025 survey.

Appendix VII. Results of Aerial Digital Surveys of Kaula Island, Hawaii (2013–2025)*

Common Name Scientific Name	Global Population and (IUCN Red List Rank)*	Hawaiian Population ² Breeding Pairs (and U.S. ESA Listing)**	State Listing§ (NatureServe Heritage Rank)¶	Aerial Digital Survey											
				4/13	8/13	1/14	1/15	7/15	3/16	7/17	8/18	11/19	7/21	8/23	7/25
Blue-billed white-tern <i>Gygis candida</i>	>100,000 breeding pairs ² (LC)	15,000	T (G4)	6	–	–	–	1	–	–	–	–	–	–	12
Brown noddy <i>Anous stolidus</i>	500,000–1,000,000 breeding pairs ² (LC)	112,000	– (G5)	57	3,713	–	–	7,137	4,115	7,871	7,612	–	3,456	11,034	1,238
Black noddy <i>Anous minutus</i>	1–1.5 million breeding pairs ² (LC)	12,000	– (G5)	–	22	–	–	–	–	–	–	–	–	–	26
Sooty tern <i>Onychoprion fuscatus</i>	60–80 million breeding pairs ² (LC)	>1,000,000	– (G5)	14,635	7	–	–	147	40,814	768	6,535	–	2,523	2,440	348
Gray-backed tern <i>Onychoprion lunatus</i>	c. 70,000 breeding pairs ² (LC)	44,000	– (G3/G4)	4	–	–	–	–	1	–	5	–	–	5	19
Unknown - Terns and Noddies	–	–		–	–	–	–	–	–	–	–	–	–	–	126
White-tailed tropicbird <i>Phaethon lepturus</i>	400,000 mature individuals ³ (LC)	–	– (G5)	–	–	–	–	–	–	–	–	–	–	–	7
Red-tailed tropicbird <i>Phaethon rubricauda</i>	> c. 32,000 individuals ¹ (LC)	9,000–12,000	– (G4/G5)	314	85	–	1	100	23	502	245	1	125	206	632
Tropicbird species <i>Phaethon</i> sp.	–	–		–	–	–	–	–	–	–	–	–	–	–	17
Laysan albatross <i>Phoebastria immutabilis</i>	1,600,000 mature individuals ³ (NT)	590,000	– (G3)	20	11	81	100	–	21	–	–	17	–	3	11
Black-footed albatross <i>Phoebastria nigripes</i>	139,800 individuals ³ (NT)	57,000	– (G5)	3	–	11	3	–	4	–	–	–	–	–	10
Band-rumped Storm-Petrel <i>Hydrobates castro</i>	150,000 mature individuals ³ (LC)	171–221 ² (E)	E (G4)	–	–	–	–	–	–	–	–	–	–	–	1

Common Name Scientific Name	Global Population and (IUCN Red List Rank)*	Hawaiian Population ² Breeding Pairs (and U.S ESA Listing)**	State Listing§ (NatureServe Heritage Rank)¶	Aerial Digital Survey											
				4/13	8/13	1/14	1/15	7/15	3/16	7/17	8/18	11/19	7/21	8/23	7/25
Christmas shearwater <i>Puffinus nativitatis</i>	c. 150,000 individuals ³ (LC)	<3,000 ²	– (G3/G4)	–	–	–	–	–	–	–	–	–	–	–	3
Great frigatebird <i>Fregata minor</i>	500,000- 1,000,000 ² (LC)	10,000	– (G4)	1,415	1,369	621	748	1,078	1,005	777	719	316	1,375	377	711
Red-footed booby <i>Sula sula</i>	> c. 1,000,000 individuals ¹ (LC)	7,000-10,500	– (G5)	1,690	191	98	209	3,693	1,319	2,650	4,764	1,196	6,016	1,369	1,417
Brown booby <i>Sula leucogaster</i>	> c.200,000 individuals ¹ (LC)	1,400	– (G5)	101	109	3	2	867	179	969	1,231	185	1,573	1,188	1,160
Masked booby <i>Sula dactylatra</i>	>100,000 birds ² (LC)	2,500	– (G5)	550	219	65	84	526	183	514	1,312	217	1,262	739	733
Masked/Red-footed booby <i>Sula dactylatra</i> / <i>S. sula</i>	–	–		–	–	–	–	27	–	24	–	–	–	228	136
Masked/Brown booby <i>Sula dactylatra</i> / <i>S. leucogaster</i>	–	–		–	–	–	–	–	–	–	51	–	–	42	9
Booby species (Masked/Red- footed/Brown) <i>Sula</i> sp.	–	–		–	–	–	–	–	–	–	713	159	184	7	81
Hawaiian monk seal <i>Neomonachus schauinslandi</i>	1,600 individuals of all age classes ⁴ (VU)	632 sexually mature seals ⁴ (E)		11	7	5	7	9	10	8	7	8	10	13	13
Total Estimated Number of Birds				18,795	5,733	879	1,145	13,576	47,664	14,075	23,187	2,091	16,514	17,638	6,697
Total Number of Bird Species				11	9	6	7	8	10	7	8	7	8	9	15

¹ del Hoyo et al. 1992² Hawaii Department of Land and Natural Resources (<http://dlnr.hawaii.gov/wildlife/cwcs/hawaii/species/fact-sheets/>)³ Birdlife International <http://www.birdlife.org/datazone/>⁴ IUCN Red List <http://www.iucnredlist.org/details/13654/0>

*UCN Red List: LC = Least Concern; NT = Near Threatened; VU = Vulnerable

**USES Listing: E = Endangered

§State Listing: T = Threatened; E = Endangered

¶NatureServe Heritage Rank: G3 = Vulnerable; G3/G4 = Vulnerable/Apparently Secure; G4 = Apparently Secure; G4/G5 = Apparently Secure/Secure; G5 = Secure